

EFFECT OF GROUNDNUT HAULMS ON SPLASH PRODUCED FROM COMPACTED AGRICULTURAL SOIL

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ABSTRACT

Splash impact represents the first stage in the erosion process; Splash characteristics in relation to effect of groundnut haulms produced from compacted Agricultural soils were studied. Soil samples were collected at 20cm depth from Dusuman, Jere local government Area of Borno state, Nigeria. Particle size analysis showed 42.90% clay, 38.70% sand and 18.40% silt and classified as clay soil. The organic matter (om) was mixed into the soil samples at 4%, 6%, and 8%. Initial moisture content (mc) of the soil was raised from 1.21% to 2%, 4%, 6% and 8%. The soil was compacted to 0, 5, 10, 15 and 20 blows. Bulk density and penetration resistance of the soil were obtained. The penetration was highest at 8% moisture content at 8% organic matter and 20 blows. Penetration resistance was minimum at 2% moisture content, 4% organic matter at 5 blows. The soil sample subjected to rainfall simulator was observed to show the rate at which the soil detachment was faster at shorter rainfall duration and decreased as rainfall duration increased indicating that the power of the falling raindrop reduces as the depth of ponding water increased. From the results obtained, detachment varied with the soil type and condition. Therefore, the problem of erosion on agricultural field can be reduced by increasing the groundnut haulm of the soil. It is recommended that similar work be carried out on other soil types and with different organic materials for better understanding of basic erosion process.

Keywords: Groundnut haulms, Splash, Compacted, Water, Erosion, Agricultural soil, Raindrop

1 INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most widely grown oilseeds in the world, especially in the tropical regions and contributes to 12% of the world oil production [1]. Production of groundnut is estimated at 47 million tonnes; 65.1 % of this production comes from China and India. African countries' production is dominated by Nigeria and Senegal (2,420,000 and 915,000 tonnes, respectively [2]. Due to its high nutritional value, groundnut contributes to the national food security and provides income to farmers [5, 6]. The crop residues especially the shell are often used as livestock feed or as fuel [5]. Like most of the leguminous, it is used for soil fertility replenishment due to its potential as biological nitrogen fixation source and it can also be used as green manure to improve nitrogen balance in the cropping systems [6]. Rain splash is an essential contributor to soil particles detachment and transport in slope erosion [7, 8]. Splash erosion is directly caused by the Kinetic Energy of raindrops [9, 10], which is an important parameter in erosion prediction models. Ground cover reduces soil erosion and surface flow on hill slope landscapes, and different vegetation conditions affect the occurrence and development of splash erosion. The two parameters used to study and predict splash erosion are the detachment rate and probability density of splashed particles within a certain distance [11, 12, 13]. Previous studies have presented the relationships between various factors and splash erosion rate by mostly considering the effects of raindrops on soil selectivity, size and distribution [9]. The distribution splashed particles at different distances is important in analyzing splash erosion. Numerous studies have considered the transport

distance of splashed particles along slopes from their origins [14]. The objective of this study was to investigate the effect of incorporating groundnut haulm at varying levels into a soil on splash detachment.

2 THE STUDY AREA

The study was conducted in the Soil and Water Engineering Laboratory, Department of Agricultural and Environmental Resources Engineering, University of Maiduguri. Soil samples were collected from Dusuman, Jere Local Government Area, Borno state, north eastern Nigeria. The Garmin's GPS (Global Positioning System, 76 S Model) was used in determining the ordinates of the and obtained as longitude $11^{\circ} 48' 15.3''$ N and Latitude $13^{\circ} 12' 10.4''$ E. (Figure 1).

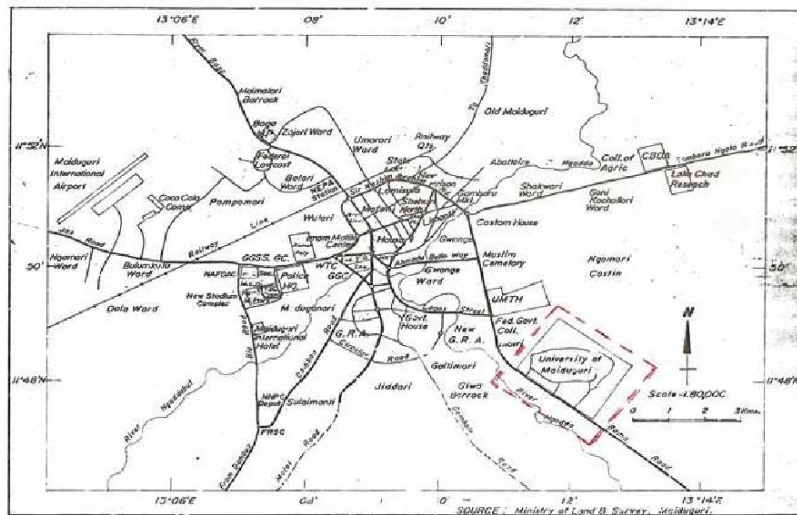


Figure 1. Map of Maiduguri showing location of the study area

3 MATERIALS AND METHODS

3.1 Materials

3.1.1 Rainfall Simulator

An existing rainfall simulator modified (Plate 1) by [15] was used for this study. It can simulate rainfall at a height of 2.65m depending on the desired intensity. The pictorial view of the assembly and operation of it are as discussed by [15].



Plate 1. The Modified Rainfall Simulator

3.1.2 The Simulator

This is the heart of the rainfall simulator; it was made by galvanized iron sheet 1mm thick and in form of a rectangular box (650mm long, 450mm wide and 200mm deep). The bottom of the box which is the base was performed, using perforated holes every spaced 10mm apart for the purpose of this experiment the mesh with 3mm perforated was used. The contacting edge was connected by welding.

3.1.3 The Ox Adjustable Stands

These are suspended perforated box above the ground level. The height of adjustable stands ranges from 1.6-2.65m the two stands were made from two galvanized iron pipes of 35mm and 28mm in diameter. 28mm pipes were fitted into 35mm pipes to enhance selection of desired height. Three 22mm diameter pipe each 100mm long were welded at about 870mm above the ground level on each of the 35mm pipe to serve as support for the stability of adjustable stands (Plate 1) in order to get the rainfall intensity of 228.6mm/hr, height of 2.65m was used for the experiments.

3.1.4 The Water Tank

This consists of a cylindrical drum 580mm in diameter and 900mm deep. A 50mm tap was connected above the tank bottom the tap control the flow of water from the tank through a 25mm hose into the perforated box. A water pump was used to pump the water from the source to the water tank and constant level was maintained. This is necessary to maintain the constant desired intensity of the rainfall. Three galvanized iron pipe were connected at 300mm, 500mm and 800mm above and in opposite of the 50mm tap centre line all the three pipe was welded at 20mm below blow the tap of the tank to serve as inlet.

3.1.5 The Water Tank Stand

These consist of galvanized iron and angular iron. Four galvanized iron pipe 54mm diameter was used, a 25mm diameter pipe was used to join the 54mm diameter pipe at a successive distance of 50mm to serve as ladder stability the stand is 3.0 above ground level the angular iron is placed at the top of the stand to serve as a base for the tank about 60mm of the 54mm was let into the ground stability.

3.2 Methods

3.2.1 Soil Sampling

The soil samples were collected from 20cm depth, air dried for 48 hours and the large clod grounded to pass through a 2mm sieve. Particle size analysis was performed using the hydrometer method. The organic matter content of the soil was estimated from the carbon content of the sample. The initial moisture content of the sieve soil was determined to be 2.21%. using least square method, The organic matter of the sample was raised from 4%, 6% and 8%, they were then mixed with the moisture content at 2%, 4%, 6% and 8%. On dry weight basis which is to correspond to various sample. The soil was packed in to polythene bags and kept airtight to prevent moisture loss and kept for 24hours to obtain a homogenous sample. Each of the soil in the mould was subjected to 0, 5, 10, 15 and 20 blows of a standard proctor hammer following the standard proctor compaction procedure as recommended by [15]. The organic materials were groundnut haulms.

3.2.2 Moisture Content Determination

Moisture content of the Dusuman clay soil sample, were determined in the laboratory by gravitational method. The soil samples were weighed and oven dried at a temperature of 105⁰ for 24hours. The oven dried samples were also weighed to get the water content. The gravimetric water content (wg) of the sample was determined from the relation below in percentage.

$$Wg = \frac{Mws + Mods}{Mws} - 1 \times 100 \quad (1)$$

Where w_g = gravimetric water content in %; m_{ws} = mass of wet soil in grams; m_{ods} = mass of oven dried soil in grams the moisture at compaction is also determine using the same procedure as above to get the exact moisture in the soil at the time of compaction [16].

3.2.3 Sample Preparation

Each soil collected was air dried grounded to pass through a 2mm sieve, each soil weighed and divided in three (3) replicate. Each sample was mixed with organic matter at 4%, 6% and 8% and the initial moisture content was 1.21% they were then mixed homogenously with water at 2%, 4%, 6% and 8% the moisture were then tied in a polythene to preserve its moisture before it is compacted. The compaction was done after 24hours in cylinder cove subjected to various compaction efforts of 0.5, 10, 15 and 20 blows of a standard proctor hammer following the standard proctor compaction procedure. The bulk density of the compacted soil is measured using the weighing scale. A hand pushed penetrometer was used to determine the penetration resistance of the compacted soil for all the compactive efforts subjected to various amount of moisture content and organic matter. The penetration of the soil in the mould was determined using a hand pushed cone penetrometer following the standard procedure. The parameter had a cone based diameter of 15mm and cone angle of 30° to determine the penetration resistance the soil in the mould were compacted in three layers with the required numbers of hammer blows and there after measurements were taken at 5mm depth. After taking the penetration resistance, the soil in were used once and discarded. The soils in the mould were compacted in three layers with the required number of hammer blows to the rainfall simulation to soil detached. Research conducted in the laboratory is generally simulated to the field condition in order to find the effect of groundnut haulm on splash procedure from compacted one agricultural soil in order to achieve the desire rainfall intensity and simulator. Plat 2 shows the penetration resistance measurement.



Plate 2. Penetration Resistance Measurement

3.2.4 Splash Measurement

Splash measurements on soils have been conducted using different devices and techniques. These techniques have resulted in the development of many proposed equations relating soil detachment to various rainfall characteristics. The Universal Soil Loss Equation is an empirical equation designed for the computation of average soil loss in agricultural fields. This equation was developed for detachment capacity limited erosion in fields with negligible curvature and no

deposition and represents soil loss averaged over time and total area. The equation has the following form. In the equation, raindrop diameters intensity and velocity were used as variable in an empirical soil detachment as shown below.

$$E = RKLSCP \quad (2)$$

Where; E is the average soil loss [MJ.mm/ha.hr.year], R is the rainfall intensity factor[SI]=17.02R[EU]), K is the soil factor, (tons per acre per unit R), LS is the topographic (length-slope) factor [dimensionless], C is the cover factor [dimensionless] and P is the prevention practices factor (dimensionless) [17].

3.2.5 Plant Residue in Reducing Soil Loss and Erosion

The most important function of plant residue is controlling soil erosion. No-till soil systems and conservation reserve program (CRP) establishment often reduce annual soil losses to less than one ton per acre. Water erosion starts with the impact of the first raindrop. If raindrops can be intercepted by plant leaves or residues such as wheat straw or sorghum stalks, the kinetic energy of the rain is expelled there. This prevents energy from reaching the soil surface and starting erosion. Efficient utilization of residues reduced runoff, sediment transport or losses, and water conservation [18]. Also, a maximum ground cover with crop residue was reported to reduce the topsoil losses to an extent of 30%. For example, legumes as a cover crops, add atmospheric nitrogen symbiotically and thus, can improve the soil health. Increases in plant density and residue mulching were reported to decrease runoff [19, 20] reported that retention of soybean residue can reduce the soil loss by 50% as compared to soil with no residue retention.

3.2.6 Detachment by Raindrops

Detachment of soil particles is mostly caused by the impact of raindrops on the soil surface. Impact was reported to be a function of several variables including the depth of overland flow, if the rain drops on the surface. The kinetic energy of the raindrops, which is converted to sound and heat energy is expressed instantly against the soil surface. Thus, compaction action experienced by the soil due to the action of falling raindrops can cause a sudden loss of capacity to infiltrate water by the soil, causing high runoff during rains. When rainfall drops strike a sloping land surface, the major portion of the splash moves downhill. As most of the splash moves downhill direction, relatively large quantities of soil may be transported by raindrop splash acting alone and aiding the entire erosion process.

3.3 Simulator Assembly Operation and Calibration

The simulator was assembled at the University of Maiduguri Agricultural Engineering workshop. The two arms of the perforated box were fixed into the upper end of the moveable pipe of the adjustable stand thus the perforated box was suspended above the ground level. The water was placed on the top of water stand. A 25mm hose was connected to the outlet tap of the tank to the inlet pipe. A 50mm water hose was connected to the inlet of the water tank to the main water tap the source of the supply. Water is directly supplied to the tank from the main tap at a desired height. The desired level of water in the tank was obtained by using appropriate overflow pipe. The outlet tap was used to control the flow from tank to the perforated box. The simulator was calibrated for intensity, uniformity of application and kinetic energy. This was calibrated at the level in the tank corresponding to the pressure of 76Kpa using a perforation of 3mm and adjusted to 2.65m height for effectiveness. The intensity of kinetic energy was computed. Typical tropical rainfall intensity for different durations of 5, 10 and 15 minutes one after the other were considered appropriate. At each simulation, the soil loss was collected from the out flow. It was allowed to settle in order to remove the water and obtain the actual soil loss. The collected soil was oven dried and weighed.

4 RESULTS AND DISCUSSION

4.1 Results of Particle Size Analysis

The particle size analysis showed the soil at Dusuman comprises of 42.40% clay, 38.70% sand and 18.40 silt was analyzed using USDA soil classification system [21] as clay. The organic

matter content of the soil was found 4.78% and organic carbon found is 2.38%. The initial moisture content of the sieve soil was found to be 1.21%.

4.2 Bulk Density and Penetration Resistance

The results obtained from all measurement of soil bulk density, penetration resistance and determination of moisture content on rainfall simulation are discussed. The results of the soil bulk density against compaction effort protector below are presented in Tables 1 to 4 at different levels of 2, 4, 6 and 8% moisture content for the clay soil, and at different levels of 4, 6 and 8% of organic matter (groundnut haulms). From the results, it was observed that the bulk density increased with increase in moisture level. It was also observed that increase in organic matter in the sample reduced the bulk density because organic matter has great potential to reduce soil compaction. The maximum bulk densities for the Dusuman clay soil at 2, 4, 6 and 8% moisture content and organic matter 4%, 6% and 8% at 20 blows of compaction effort were 1.55, 1.64, 1.69, 1.78 and 1.93 kg/m³ respectively. This shows that increases in organic matter the bulk density values of the soil reduced. The results in Tables 1 to 12 suggested that the density of 2% moisture content and 4% organic matter at 0 blows for the soil produced the least density and 8% moisture content and 8% organic matter 20 blows produced the highest bulk density. This is because the organic matter added to the soil will make the soft together and compacted. The results obtained are supported by [22].

Table 1. Effect of 4% level of groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 2% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.32	0
5	177	1.38	0.08
10	287	1.46	0.26
15	352	1.50	0.30
20	398	1.53	0.36

Table 2. Effect of 6% level of groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 2% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.35	0
5	177	1.41	0.05
10	287	1.46	0.14
15	352	1.50	0.18
20	398	1.55	0.21

Table 3. Effect of 8% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 2% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow(kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.33	0
5	177	1.40	0.10
10	287	1.46	0.16
15	352	1.50	0.22
20	398	1.55	0.25

Table 4. Effect of 4% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 4% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.32	0
5	177	1.48	0.130
10	287	1.55	0.24
15	352	1.60	0.28
20	398	1.64	0.33

Table 5. Effect of 6% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 4% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.45	0
5	177	1.47	0.25
10	287	1.52	0.41
15	352	1.54	0.49
20	398	1.56	0.56

Table 6. Effect of 8% level of groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) 4% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (Kpa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.45	0
5	177	1.53	0.10
10	287	1.56	0.11
15	352	1.57	0.14
20	398	1.58	0.16

Table 7. Effect of 4% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 6% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.25	0
5	177	1.48	0.12
10	287	1.52	0.28
15	352	1.63	0.32
20	398	1.69	0.40

Table 8. Effect of 6% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m³) and penetration resistance (mpa) at 6% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m ³)	Penetration Resistance (mpa)
0	66.7	1.27	0
5	177	1.48	0.25
10	287	1.60	0.41
15	352	1.67	0.48
20	398	1.71	0.56

Table 9. Effect of 8% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m^3) and penetration resistance (mpa) at 6% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m^3)	Penetration Resistance (mpa)
0	66.7	1.25	0
5	1.77	1.43	0.23
10	287	1.47	0.39
15	352	1.52	0.48
20	398	1.57	0.54

Table 10. Effect of 4% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m^3) and penetration resistance (mpa) at 8% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m^3)	Penetration Resistance (mpa)
0	66.7	1.25	0
5	1.77	1.71	0.16
10	287	1.75	0.20
15	352	1.85	0.36
20	398	1.93	0.41

Table 11. Effect of 6% groundnut haulm added to clay soil subjected to various level of compaction on soil bulk density (Kg/m^3) and penetration resistance (mpa) at 8% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m^3)	Penetration Resistance (mpa)
0	66.7	0.89	0
5	1.77	1.36	0.16
10	287	1.46	0.18
15	352	1.52	0.36
20	398	1.61	0.41

Table 12. Effect of 8% groundnut haulm added to clay soil subjected to various levels of compaction on soil bulk density (Kg/m^3) and penetration resistance (mpa) at 8% MC

Number of Blows	Static Equivalent Pressure of Proctor Compaction Blow (kPa)	Bulk Density (Kg/m^3)	Penetration Resistance (mpa)
0	66.7	0.89	0
5	1.77	1.36	0.16
10	287	1.46	0.18
15	352	1.52	0.32
20	398	1.61	0.41

The results showed that the penetration resistance increased due to increase of organic matter into the soil sample. It reduces the penetration resistance because organic matter has great potential to reduce soil compaction. The maximum penetration resistance of the soil at 2% moisture content 20 blows and the organic matter (groundnut haulm) at 2, 4, 6 and 8% organic matter were 0.56, 0.54, 0.41 and 0.25 mpa for Dusuman clay soil respectively. This indicated that addition of organic matter reduced the penetration resistance of the soil. The penetration was highest at 8% moisture content at 8% organic matter and 20 blows. Penetration resistance was minimum at 2% moisture content, 4% organic matter at 5 blows which is in line with the research by [23].

4.3 Moisture Content on Rainfall Simulator and mount of Splash Compaction Level

The results obtained from soil detachment on rainfall simulator were shown in Tables 13 to 16 and observed that increase of organic matter into a soil sample resulted in higher detachment values. This is based on the fact that organic matter has great potential to reduce soil compaction.

Table 13. Effect of groundnut haulm added to clay soil subjected to various levels of compaction on rainfall simulator detachment at 2% MC

Number of Blows	5 min Splash at 4% om	10 min Splash at 6% om	15 min Splash at 8% om
0	8.6777	10.643	14.106
5	12.259	19.504	18.672
10	16.475	20.935	20.744
15	18.450	26.482	36.521
20	20.418	30.966	48.111

Table 14. Effect of groundnut haulm added to clay soil subjected to various levels of compaction on rainfall simulator detachment at 4% MC

Number of Blows	5 min Splash at 4% om	10 min Splash at 6% om	15 min Splash at 8% om
0	7.2427	11.316	11.734
5	10.615	12.809	12.686
10	12.863	15.703	19.018
15	13.214	16.982	19.722
20	14.253	18.535	20.176

Table 15. Effect of various levels of groundnut haulm added to clay to clay soil subjected to various levels of compaction on rainfall simulator detachment at 6% MC

Number of blows	5 min Splash at 4% om	10 min Splash at 6% om	15 min Splash at 8% om
0	7.9278	7.0553	12.918
5	8.7292	6.8130	14.226
10	10.398	12.106	23.601
15	10.462	12.448	38.342
20	11.107	12.927	42.948

Table 16. Effect of various levels of groundnut haulm added to clay soil subjected to various levels of compaction on rainfall simulator detachment at 8% MC

Number of Blows	5 min Splash at 4% (om)	10 min Splash at 6% (om)	15 min Splash at 8% (om)
0	6.5113	7.7069	7.4223
5	7.0416	9.3892	11.342
10	7.3520	12.979	18.435
15	9.882	13.448	25.742
20	11.912	13.991	27.361

The amount of splash obtained at compaction levels of 0, 5, 10, 15 and 20 blows at 2, 4, 6 and 8 moisture contents during the compaction process water is being released by the soil into mould which cause considerable damage to the structure. Groundnut haulm has high binding effect on the soil and therefore did not allow water to be released easily [23].

5 CONCLUSIONS

It can be concluded from the results obtained using the rainfall simulator that the relationship between groundnut haulm and the amount of particles detached as a result of splash erosion has been established. This shows that as the groundnut haulm percentages in the soil increase at different levels

of compaction, the amount of splash decreases. Results obtained also show that rainfall duration affects splash which signifies a decrease in stability of aggregate as the duration of rainfall increases. It was observed that the rate at which the soil detaches was faster at shorter rainfall duration and decreases as rainfall duration increased indicating that the power of the falling raindrop reduces as the depth of ponding water increases. From the result obtained, it may vary with the soil type and condition the problem of erosion on agricultural field can be reduced by increasing the groundnut haulm of the soil.

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